

Peer Review File

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Reviewer A

The authors of the article deal with an interesting approach to MOWHTO. Different influences on MTPA and tibial slope are analyzed. The paper has a coherent structure, but I still see some points that should be improved. The study contains interesting results, but these are not presented concisely enough and discussed with the current literature. The following are comments on the sections:

Abstract

Comment 1: Specify intention of the study – it is too general.

Reply 1: Agree, I tried to specify to surgical osteotomy steps

Changes in the text: “Not all surgical osteotomy steps have been properly investigated for their potential impact on surgical accuracy” (line 29-30)

Comment 2: Conclusion is too long and should be modified - see following

Reply 2: Agree, the conclusion was shortened and more suitable to the findings

Changes in the text: “The study showed that the medio-lateral osteotomy length is the main parameter for obtaining bony accuracy in the coronal plane and maintaining a strict perpendicular axial hinge axis position is crucial in preserving the native tibial slope. Correct axial alignment of the hinge axis can be obtained by creating an equal osteotomy depth of the anterior and posterior tibial cortices in the lateral metaphyseal area.” (Line 51-56)

Introduction:

Comment 3: The Hernigou table is discussed in the introduction with corresponding points of criticism. It would make sense to take this up again in the discussion or to move it there and discuss it with study results. Please state clearly at the end of the introduction which parameters are examined and which influencing variables are taken into account. "Amount of intended correction" does not appear later. Include more references for 3D analysis, name what is new in your study.

E.g. <https://doi.org/10.1002/jor.24263>, <https://doi.org/10.1177/10225536221101699>, <https://doi.org/10.1007/s00167-015-3571-2>

Reply 3: The Hernigou table is well established in osteotomy surgeons and I would like

to keep this in introduction as a ‘translation tool’ from planning to surgery with regards to the correction amount. Nevertheless, I transferred the drawbacks (Line 81-84) of this table to the discussion section (line 239-243). The amount of correction is discussed in the discussion section and seems relevant given that smaller tibias (giving more shallow osteotomy lengths) bear a higher risk of in coronal inaccuracy. The proposed references were added where appropriate in the introduction.

Changes in the text: Several parts were rephrased in the introduction. See track changes.

Comment 4: Line 84: ACL can be deleted (not used in the paper)

Reply 4: To outline the importance of maintaining native tibial slope and the risks of increasing it after MOWHTO, I think increased strain on the ACL is a valid clinical argument to consider

Changes in the text: None.

Methods:

Comment 5: The methodology is presented in a clear and comprehensive manner. However, there are still some points that should be optimized or explained: Only parameters should be explained which are also relevant for understanding the simulation or and in the results section. TJJ/MSP is not of major importance in the article and should be removed accordingly.

Reply 5: The MSP parameter was deleted since indeed of no importance. An additional figure was added (suggestion by other reviewer) to make the axes and angles clearer to the reader with limited background information.

Changes in the text: Figure 1 was added and all other figures were renumbered appropriately. The caption of figure 1 was added at the end of the manuscript (line 354-356).

Comment 6: Line 103 - Replace Chapter 2 and section 2.3 - use subheading

Reply 6: Chapter 2 and section 2.3 was a writing mistake. This was deleted and the methodology was properly explained.

Changes in the text: “The CT-scan protocol for the knee joint was a 0.5mm thickness and spacing, captured in 150mm centered range. DICOM-files were loaded in medical image software Mimics 23.0 (Materialise®, Leuven, Belgium) with segmentation threshold set at 130-200 HU. The final 3D reconstruction was exported as STL-files and opened in medical 3D planning software 3-matic 14.0 (Materialise®, Leuven, Belgium) in which all measurements, simulations, axes and plane definitions were conducted.” (line 105-109)

Comment 7: Line 104 -106 move to Line 101

Reply 7: As suggested by the other reviewer, the first part of the method section was rewritten.

Changes in the text: -

Comment 8: Line 111: Delete sentence with redefining.

Reply 8: Adjusted.

Changes in the text: -

Comment 9: Line 121: PCL can be misunderstood and condylar lines should be the posterior tibial plateau boundary

Reply 9: Adjusted (line 130)

Changes in the text: PCL => PTPB, changed throughout the manuscript

Comment 10: Line 126 ... repressed the tibial slope PLANE (?)

Reply 10: This was changed as suggested by the other reviewer. Medial was deleted since not measured. Lateral slope plane (LSP) was only used.

Changes in the text: Line 137

Comment 11: Line 130: Slope measured by MSP/LSP cut with TSP? or what are the slope points?

Reply: Yes, the lateral tibial slope angle was measured by the anatomical tibial axis (ATA) and the lateral slope plane (LSP) while projecting in the tibial slope plane (TSP). All the points for these planes and axes are defined and described.

Gap distraction is measured at the posteromedial - where? Why not at the starting point of the osteotomy? What is the gap there?

Reply: Gap distraction was indeed measured at the most medial point (so posteromedial in 3D) on a strict coronal view of the proximal tibia. This methodology was repeated for all simulations and measurements. This is the starting point of an osteotomy. Measuring the gap distraction in the antero-posterior middle of the tibia would yield a smaller gap distraction for the same correction (in degrees), at least if one wants to maintain the native tibial slope.

How was the opening performed? By hand? Simulation? Scripting? Which program?
Measuring Osteotomy depth - True length or axial length? Always from medial or starting point of osteotomy? Please describe this in methods

Reply 11: Gap distractions were all performed in 3D software for osteotomy simulations (line 105-112) – 3-matic® software. ‘Osteotomy depth’ was overall changed to ‘osteotomy length’ since this seems to point out more the medio-lateral depth of the osteotomy. However, it was added and clarified in methodology. The medio-lateral osteotomy length was measured from the posteromedial starting point to the simulated hinge axis (also see discussion).

Changes in the text: line 148-159.

Results

Comment 12: A due to the different osteotomy depths and heights, the results are sometimes confusing. if you are interested in osteotomy depth than please expand this give more details.

Reply 12: Agree. Having the table of the result part next to the text should make it possible to interpretant the data correctly. The coronal simulation section was slightly extended to ease interpretation. Although I think that details should remain in the table and the general result of this simulation section is described in the text.

Changes in the text: line 190-199

Comment 13: B four tilted hinges and on basline value - not five simulations with tilted hinge axis

Is general / average? Please specify.

Reply 13: yes, 0° tilt was also considered to be a simulation but this was indeed done to set the baseline for the other simulations. The maximum decrease or increase is always described because this is the highest difference between simulations that can be expected. I understand the confusion with ‘general’ so I deleted these values throughout the sections. Again, the table should be used to comprehend the data.

Changes in the text: deletion of ‘general’ values since not relevant and confusing

Discussion:

Comment 14: The main finding is the relevance of the hinge axis. The osteotomy depth is consecutive and depends on the direction of the cut. Is this strictly medial, then the results of the study apply, otherwise these will probably deviate and are not transferable to the clinic (medial ligament as mentioned, cut often from anteromedial, also measurement, please discuss or modify measuring osteotomy depth).

Reply 14: We tried to give the parameter of osteotomy length (and so tibial plateau size) more value by explaining the relevance of the starting point of the osteotomy in the second part of discussion (line 235-252). Also, the criticism of the Hernigou table from

the introduction was digested in this part. The osteotomy length was measured as described by Hernigou (2001), the starting point most medial on a plain view of the proximal tibia (so posteromedial in 3D because of the triangular shape of the proximal tibia) and the direction of the osteotomy length in line with the coronal plane (3D).

Changes in the text: Mainly adding explanation to the coronal hinge axis translation section – relevance of osteotomy length on coronal bony accuracy (line 235-252)

Comment 15: Line 206 1.0-1.3° (?)

Reply 15: correct, this 1.4° was changed to 1.3°

Changes in the text: line 226

Comment 16: line 205 et seq. - this part is too difficult to follow. Maybe it is useful to expand table 1. But right now, it is not easy to understand which osteotomy depth is mentioned and the correlation to the MPTA is not explained enough

Reply 16: I do understand. We have the coronal translations of the hinge axis on one hand which influence the osteotomy length (and so the actual bony correction MPTA°) and we have the gap distraction simulations on the other side (5-10-15 mm opening). Table 2 tries to summarize the 8 simulations and should be kept close when reading. The second section of discussion was rewritten with most important findings and relevance of the coronal simulations

Changes in the text: line 228-255

Comment 17: line 234 interesting point but is the osteotomy depth measured not from medial? See above

Reply 17: Exact, this is measured from medial.

Changes in the text: Changed accordingly in the text.

Comment 18: Line 246 this is already known

Reply 18: Okay

Changes in the text: -

Comment 19: Line 249/253 /table 2 please highlight SD by +/- and for osteotomy depth analyzing please expand table 1 and discuss osteotomy depth on its own.

Reply 19: SD was added to table 2 caption to explain abbreviation. As mentioned above, I think the relevance of osteotomy depth is well discussed now.

Changes in the text: See above.

Comment 20: Line 261: 3D cutting guides should not be mentioned here without further

ado, as the osteotomy depth is only measured axially. This cannot be measured intraoperatively. also, the axial direction is always indicated regardless of the cutting direction. I recommend removing this part and discussing your own results more.

Reply 20: Agree, this part was removed from discussion

Changes in the text: removal of line (308-316)

Comment 21: Generally, if you are interested in osteotomy depth, provide more data and relate this to the clinic. The discussion should be more related to the actual literature (more references) and not extend your results section. Please tighten the discussion and set your findings in context and highlight the new findings.

Reply 21: We tried to rewrite the discussion accordingly.

Changes in the text: Whole discussion.

Conclusion:

Comment 22: Accordingly, to the points above and your hypothesis – update and shorten it

Reply 22: Agree, the conclusion was shortened and more suitable to the findings

Changes in the text: “The study showed that the medio-lateral osteotomy length is the main parameter for obtaining bony accuracy in the coronal plane and maintaining a strict perpendicular axial hinge axis position is crucial in preserving the native tibial slope. Correct axial alignment of the hinge axis can be obtained by creating an equal osteotomy depth of the anterior and posterior tibial cortices in the lateral metaphyseal area.” (line 318-322)

Figures:

Comment 23: Table 1: alignment parameter instead of features; only one decimal place. Is slope 91.73° the common mentioned 1.73° or $101.8^\circ - 11.8^\circ$?

Reply 23: Adjustments were performed. The medial slope row was deleted since not relevant for the paper. A slope of 101.8° is indeed 11.8° slope etc.

Changes in the text: Removed row in table 1.

Comment 24: Tab 2: Osteotomy depth interesting but to general, if main finding.

Reply 24: depth was changed to length. It was kept in the table to outline the average osteotomy length per tibial plateau size and to outline a maximal difference of 10mm between the shortest and the longest osteotomy for each model.

Changes in the text: -

Comment 25: Table 3: osteotomy depth is axial discuss sense by oblique cuts in clinic => discussion

Reply 25: indeed. Changed to osteotomy length again. The way it was measured was discussed in discussion with relation to the anteromedial osteotomy cut in clinic.

Changes in the text: - (add discussion line 245-253)

Comment 26: Table 4 I Think Osteotomy depth is not right here – for this there is table 5?

Reply 26: The osteotomy depth/length was mentioned for all simulations, so also during anterolateral rotations in the axial plane of the hinge axis

Changes in the text: -

Reviewer B

Comment 27: I found it to be an engaging read, despite the intricacy of the model. Typically, complex models tend to lose readers' interest, but the straightforward and accessible writing style of this article facilitates continuous reading and allows for a deeper understanding of the details.

The utilization of three-dimensional simulations to construct models for the examination of surgical operations is an innovative and promising avenue. It has the potential to significantly enhance surgical methods and precision in the future. However, one limitation of the article is the relatively small number of cases presented (3).

Reply 27: Thank you for reviewing our manuscript. Only 3 proximal tibia models were included to illustrate relevant and irrelevant factors regarding osteotomy plane positioning on accuracy. With this study, the authors want to give surgeons clinical insights on coronal realignment and tibial slope consequences while using realistic gap distractions and osteotomy simulations. Creating mathematical models would have been an option if more cases were included, however the authors estimated that this illustrative study would be more comprehensible and clinically relevant from a surgical perspective instead.

Changes in the text: ‘merely’ was added in discussion (limitation) – line 303

In relation to the METHODS section, I have a couple of minor suggestions:

Comment 28: On line 100, it would be beneficial to clarify the criteria used to determine the size of the tibia as either large, small, or medium.

Reply 28: Our 3D osteotomy database (n=20) was searched for tibial plateau width. Given the average tibial plateau width for males and females (Kumar et al. 2020 doi: [10.1016/j.jcot.2019.06.006](https://doi.org/10.1016/j.jcot.2019.06.006)), it was found that the smallest and largest tibial plateau was respectively 70mm and 85mm. A third model was positioned in the middle of these sizes to determine the gradual increase in size during simulations.

Changes in the text: Reply 28 was added to the text with inclusion of the reference work by Kumar et al. (2020) (line 113-117).

Comment 29: Building on the previous point, on line 106, it would be helpful to explain the rationale behind selecting these specific sizes over others. Is it based on an average, or does it draw from findings in other articles?

Reply 29: I think the same answer is applicable here as in the previous comment.

Changes in the text: Reply 28 was added to the text with inclusion of the reference work by Kumar et al. (2020) (line 113-117).

Comment 30: Consider including a drawing of ATA on line 108. Readers who are not familiar with 3D models may not be acquainted with this measurement. Additionally, provide details on how this measurement will be enforced.

Reply 30: A new figure was created (1) to provide a better overview of the angles and axes defined

Changes in the text: -

Comment 31: Similar to the suggestion above, provide drawings for measurements such as TJL, PCL, PTP, and TSP. This visual aid will assist readers who may not be well-versed in 3D models and help them understand the measurements more comprehensively.

Reply 31: A new figure was created (1) to provide a better overview of the angles and axes defined

Changes in the text: -

Comment 32: Overall, the article is commendable for its accessible writing and innovative approach. Addressing these minor concerns would further enhance the clarity and completeness of the work.

Reply 32: Thank you. We hope your concerns were well addressed.

Changes in the text: -